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E: ISSN NO.: 2349-980X **Shrinkhla Ek Shodhparak Vaicharik Patrika**

Evaluation of Accident Severity at Intersections

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Abstract

The increase in number of motor vehicles on the road has created a major social problem – the loss of lives through road accidents. The increasing number of motor vehicles on the roads across the world has made the issue of accident prevention an urgent one. Accident analysis is conducted to uncover the enabling factors so that measures can be identified and implemented to prevent a recurrence.Based on the location accidents can be divided into two groups – accidents at midblock and accidents at intersections. The road geometry, traffic control, light conditions, etc. at the intersection points are different from those at midblock locations. Accident causes and preventive measures at each of the above-mentioned accident type may be different. This work will conduct research to identify the factors that are associated with the severity of accidents at different types of intersections in Vadodara city, as well as the severity of accidents happening during different time periods at all intersections, including vehicle characteristics, crash characteristics, victim characteristics and roadway features. Multi-nomial logistic regression is used to identify the correlation between various factors considered and severity of accident at the intersection – Minor, Major or Fatal. Day or night, collision type, junction type, posted speed, number of lanes and type of impacting vehicle were all found to be significantly affecting the accident severity of crashes at unsignalized intersections in Vadodara city. Day or night, collision type, junction type, number of lanes and type of impacting vehicle are found to be significantly affecting accident severity of motorcycle crashes at all intersections in Vadodara city.

Keywords: Accident Severity, Intersections, Road Safety, Multinomial Logistic Regression.

Introduction

Transportation plays a vital role in the prosperity of societies. Road Network is the heart of a nation and transport services are considered as growth engines of the country. The growth in trade, commerce, and industry depends directly on the development of roads of a country.Because of its intensive use of infrastructures, the transport sector is an important component of the economy and a common tool used for development. This is even more so in a global economy where economic opportunities have been increasingly related to the mobility of people, goods and information. High density transport infrastructure and highly connected networks are commonly associated with high levels of development. However, with the positive qualities, the by-product of transportation is pollution and accidents.

Road accidents have been one of the greatest health hazards. Accidents are defined as unintended events that result in injury, illness, or material loss. Safety professionals regard accidents and incidents as preventable events that indicate correctable deficiencies in an organization's safety and loss-control system. The accidents on roads are pronounced and disastrous. Road accidents is a negative externality associated with expansion in road network, motorization and urbanization in the country. Road traffic injuries are recognized, globally, as a major public health problem, for being one of the leading causes of deaths, disabilities and hospitalization, imposing huge socio-economic costs.

Road use patterns in Indian cities are very different from those in cities in highly industrialized countries. Pedestrians, two-wheeler users, and bicyclists are considered as vulnerable road users. Among the vehicle categories, two wheelers accounted for the highest share in total number of road accidents (33.8 per cent) in 2016, followed by cars, jeeps and taxis (23.6 per cent), trucks, tempos, tractors and other articulated vehicles (21.0

per cent), Buses (7.8 per cent), Auto-Rickshaws (6.5 per cent) and other motor vehicles (2.8 per cent). The share of two wheelers in total road accidents has increased from 28.8 per cent in 2015 to 33.8 per cent in 2016.

The assessment of the occurrence of road accidents and the management of infrastructure to deal with this risk are therefore research areas of considerable interest. Numerous studies have been performed to identify the most important risk indicating variables that contribute to the occurrence of road accidents. After an accident occurs, an accident analysis is done. The process generally involves systematic collection, documentation and communication of relevant information. Following the outcome of an accident analysis, the relevant authorities may review the existing safety policy, update risk assessment or controls, and update the safety statement for the organization.

Transportation in the urban areas is of the highest importance. By and large, the roads of urban areas form a grid system, that is, the roads are closely intersected to greatly connect the parts of the cities. Intersections play an important role in functioning of the street and road network. Safety is paramount in transportation, therefore due to many intersections in cities, we need to investigate crashes occurring at and around an intersection.

Gujarat is one of the most industrially developed and agriculturally advanced fertile state of India. The population of Gujarat has increased from 4.13 crores in 1991 to 5.06 crores in 2001 to 6 crores in 2011 and 6.71 crores in 2017. (Census, 2017) The road length in Gujarat has increased from 47426 km in 1981 to 67065 km in 1991 to 79619 km in 2011. With increased in road length, the total number of registered vehicles in Gujarat has increased from 102890560 in 2007-2008 to 23286418 in 2017-2018. (RTO, 2017) Gujarat state is having a vehicle ownership rate of 100.6 motor vehicles per 1000 persons in 2011, as against the average annual national vehicle ownership of 53.5 motor vehicles per 1000 persons as per statistics pertaining to 2011. There is increase in number of accidents from 2103 in the year 1961 to 30205 in the year 2011 to 19081 in the year 2017. (RTO, 2017) The rate of accidents in Gujarat is 12.4 accidents per 10000 vehicles. (MoRT&H, 2016)

Aim of the Study

To get an insight into the trend of road accidents at intersections in Vadodara, with respect to age and sex distribution of victims, types of vehicle involved, road features, time of accident and collision characteristics.Development of relationship between road, vehicle, victim, collision characteristics and accident severity for vehicle accidents by developing accident severity model based on multi-nomial logistic regression model.In this study accident scenario of urban area is discussed. To limit the scope of this study the area under Vadodara police jurisdiction of Gujarat state is taken as study area. Accident data is collected from various police station and police commissioner office of Vadodara city. Preliminary analysis and detailed analysis of accident data has been carried out. Accident Severity models are developed considering different types of impacting factors.

Review of Literature

Intersections are recognized as being among the most hazardous locations on the roads (PIARC, 2003). For example, about 43% of all crashes in the United States occur at or near an intersection and about 40% of all casualty crashes in Norway occur at junctions (Elvik, 2004).

Tay (2007) did research on factors contributing to the severity of intersection crashes. Anordinal probit model was applied to crash data to investigate the role a variety of factors play in determining the severity of intersection crashes. Vehicle type, road type, collision type, driver's characteristics and time of day were found to be important determinants of the severity of crashes at intersections in Singapore.Manan (2017) studied the road characteristics and environment factors associated with motorcycle fatal crashes in Malaysia. Multinomial and mixed models of motorcycle fatal crash outcome based on the number of vehicle involved were estimated.The estimation results suggest that curve road sections, no road marking, smooth, rut and corrugation of road surface and accidents between 00:00 am to 6 am increase the probability of motorcycle single-vehicle fatal crashes and factors such as expressway, primary and secondary roads, speed limit more than 70km/h, roads with double lane line and daylight condition are found to cause an increase the probability of motorcycle fatal crashes involving multiple vehicles.

Abdel-Aty (2005) explored the overall and specific crash severity levels at signalized intersections using ordered probit model. The probit model results showed that, having a divided minor roadway or a higher speed limit on the minor roadway decreased the level of injury while crashes involving a pedestrian/bicyclist and left turn crashes had the highest probability of a more severe crash.Kockelman (2002) applied ordered probit models to study driver injury severity. The results suggest that pickups and sport utility vehicles are less safe than passenger cars under single-vehicle crash conditions. In two-vehicle crashes, however, these vehicle types are associated with less severe injuries for their drivers and more severe injuries for occupants of their collision partners. The results also indicate that males and younger drivers in newer vehicles at lower speeds sustain less severe injuries.

Yan (2005) studied the characteristics of rear-end accidents at signalized intersections using multiple logistic regression model. Seven road environment factors(number of lanes, divided/undivided highway, accident time, road surface condition, highway character, urban/rural, and speed limit), five factors related to striking role (vehicle type, driver age, alcohol/drug use, driver residence, and gender) and four factors related to struck role (vehicle type, driver age, driver residence, and gender) are associated with the risk of rear end accidents.Tay (2007) used a logistic model to study the effects of roadway, environmental, vehicle, crash and driver characteristics on hit-and-run crashes. This study found that drivers were more likely to run when crashes occurred at night, on a bridge and flyover, bend, straight road and near shop houses; involved two vehicles, two-wheel vehicles and vehicles from neighbouring countries; and when the driver was a male, minority, and aged between 45 and 69. On the other hand, collisions involving right turn and U-turn manoeuvres, and occurring on undivided roads were less likely to be hit-and-run crashes.

Sze (2006) analyzed the pedestrian injury severity in traffic crashes using logistic model. The sex and age of the casualty, injury location, pedestrian location and action and special circumstances of the crash, time of day, speed limit, congestion, junction controls, road type and geometry, and environmental contributory factors were all found to significantly determine the probability of mortality and severe injury.Michalaki (2015)explored the factors affecting motorway accident severity in England using the generalized ordered logistic regression model. They compared the most important factors affecting the severity of Hard shoulder and Main Carriageway accidents on motorways in England. Differences between Hard Shoulder and Main Carriageway accidents are identified, with the most important being the involvement of heavy goods vehicles (HGVs) and driver fatigue, which was found to be more crucial in increasing the severity of Hard Shoulder accidents.

Kononen (2010) identified and validated a logistic regression model for predicting serious injuries associated with motor vehicle crashes. The parameters to be used for crash injury prediction were crash direction (front, left, right, and rear), change in velocity, multiple vs. single impacts, belt use, presence of at least one older occupant, presence of at least one female in the vehicle, and vehicle type (car, pickup truck, van, and sport utility). Ali S. (2000) used logistic regression to estimate the influence of accident factors on accident severity. Of nine independent variables obtained from police accident reports, two were found most significantly associated with accident severity, namely, location and cause of accident. Chin (2001) applied the random effect negative binomial model to examine traffic accident occurrence at signalized intersections. The total approach volumes, the numbers of phases per cycle, the uncontrolled left-turn lane and the presence of a surveillance camera were among the variables that are the highly significant.

Haque (2009) applied Bayesian hierarchical models to examine motorcycle crashes at signalized intersections. The study found that the number of lanes at the four-legged signalized intersections significantly increases motorcycle. For T signalized intersections, the presence of exclusive right-turn lane at both major and minor roadways and an uncontrolled left-turn lane at major roadways increases motorcycle crashes. Ali S. (2001) analyzed traffic accidents at urban intersections in Riyadh using conditional probability. The study found that improper driving behavior is the primary cause of accidents at signalized urban intersections in Riyadh; running a red light and failing to yield are the primary contributing causes.Mussone (2017) analyzed the factors affecting the severity of crashes in urban road intersectionsusing a back propagation neural network model and a generalized linear mixed model. Both methods demonstrated that flows play a role in the prediction of severity levels.Haleem (2015) identified and compared the significant factors affecting pedestrian crash injury severity at signalized and unsignalized intersectionsusing the mixed logit model. At signalized intersections, higher AADT, speed limit, and percentage of trucks; very old pedestrians; at-fault pedestrians; rainy weather; and dark lighting condition were associated with higher pedestrian severity risk.

Data

Accident data were collected from the Vadodara police department. Fatal accident, major injury, minor injury and non-injury data come under the IPC 304 A, 338, and 337 & 279 respectively. For the purpose of grouping the data in above format, it was collected from numerous police stations of Vadodara City in the form of FIR (First Information Report)

A total accident data was collected for years 2013-2017. This data included 3220 accidents between all types of vehicles and pedestrian. Further the study of data revealed that, 43 accidents were recorded as severity of as property damage only. Further, out of all the accidents recorded, 988 accidents were recorded as severity of minor, 1626 accidents were recorded as accident severity of major and 563 accidents were recorded as accident severity of fatal.The hourly variation of all accident data collected shows that the maximum number of accidents occur between 10 AM to 11 AM in the morning and between 8 PM and 9 PM in the evening. These time periods in morning and evening can be considered as peak hours. As most offices, businesses and schools open and close around those time periods. That may be why the number of accidents is the highest between those time periods in the morning and evening.

Out of all the Accidents, 2137 accidents occurred on a mid-block, while 1033 accidents occurred at intersections and 50 accidents occurred at other spots. The safety measures such as traffic signals, policemen are usually prioritized at intersection rather than at mid-blocks. That may be why the number of accidents are more at mid-block than at intersections.The focus of this study are the accidents that occurred at intersections in Vadodara city from 2013 to 2017. So, the next section details the data analyzed solely for the crashes occurring at intersections.

Total accidents reported in Vadodara city between 2013 to 2017 are 3220. Out of which 2137 accidents were reported to have occurred on mid-block, while 1033 accidents occurred at intersections. Total accidents occurring at intersections were 1033. Out of these 1033 accidents, 730 accidents occurred at unsignalized intersections and 75 accidents occurred at signalized intersections. 228 accidents occurred at roundabout intersections.

Methodology

Multinomial logistic regression (often just called 'multinomial regression') is used to predict a nominal dependent variable given one or more independent variables. It is sometimes considered an extension of binomial logistic regression to allow for a dependent variable with more than two categories. As with other types of regression, multinomial logistic regression can have nominal and/or continuous independent variables and can have interactions between independent variables to predict the dependent variable.The multinomial logit model can be expressed mathematically as, for K possible outcomes, running K-1 independent binary logistic regression models, in which one outcome is chosen as s pivot and then the other K-1 outcomes are separately regressed against the pivot outcome. If outcome K (last outcome) is chosen as pivot:

$$\ln\frac{P_r(Y_i=1)}{P_r(Y_i=K)} = \beta_1 . X_i$$

$$\ln\frac{P_r(Y_i=2)}{P_r(Y_i=K)} = \beta_2 . X_i$$

So,

$$\ln\frac{P_r(Y_i=K-1)}{P_r(Y_i=K)} = \beta_{K-1} . X_i$$

Where β is the regression coefficient associated with the respective explanatory variable and outcome. X is the set of explanatory variables associated with the outcome. Here $\ln\frac{P_r(Y_i=K-1)}{P_r(Y_i=K)}$ represents the odds ratio of any given outcome.

Results

Model 1 - Vehicle crashes at unsignalized intersections

The model is developed to see which of the parameters taken into consideration influence the severity of the accidents occurring at unsignalizedintersections in Vadodara city. The accident severity is the dependent variable. It is a categorical variable. The three categories of accident severity are minor accidents, major accidents and fatal accidents.

Analysis is done by using multinomial logistic regression. Minor accident is taken as the reference category. The parameters considered for the regression included: Day or night, weekday, holiday, hit and run, collision type, junction type, posted speed, intersection angle, number of lanes, impacting vehicle type, impacting vehicle driver gender, victim type, victim vehicle type, victim sex and victim age group.

The confidence interval is set at 90 %. So, the parameters whose p-value (shown under the *Sig.* column in the parameter estimates table) are < 0.1 are said to have an impact on the dependent variable (i.e. accident severity). The parameters whose p-value was very high than 0.1 are eliminated. Then after trial and error of different combinations of the remaining parameters the final parameters taken into consideration are: Day or night, collision type, junction type, posted speed, number of lanes and impacting vehicle type.

The parameter estimates table of the multinomial logistic regression performed using these parameters as independent variables and accident severity as dependent variable is discussed below.

Goodness of Fit

Table 1.1 Goodness of Fit Table for Crashes at Unsignalized Intersections

	Chi-Square	df	Sig.
Pearson	313.063	316	.536
Deviance	314.828	316	.508

First row of the table 1.1 present Pearson chi-square statistic. According to *laerd statistics* for multinomial logistic regression,a statistically significant result (i.e. p < 0.1) indicates that the model does not fit the data well. As seen in the table above the p-value is .536 and is, therefore not statistically significant. Based on this measure, the model fits the data well. It can also be verified by the deviance chi-square statistic presented in the second row.

Parameter Estimates

Table 1.2 Parameter estimates for crashes occurring at unsignalized intersections

Accident Severity[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	90% Confidence Interval for Exp(B) Lower Bound	Upper Bound
3	Intercept	.613	.628	.951	1	.329			
	[Day_or_Night=1]	-.348	.201	2.986	1	.084	.706	.507	.983
	[Day_or_Night=2]	0[b]	.	.	0	.	.	.	.
	[collision_type=2]	-.178	.457	.153	1	.696	.837	.395	1.774
	[collision_type=3]	-.141	.449	.098	1	.754	.869	.415	1.818
	[collision_type=4]	-.480	.426	1.271	1	.260	.619	.307	1.246
	[collision_type=11]	0[b]	.	.	0	.	.	.	.
	[Junction_Type=1]	1.214	.430	7.975	1	.005	3.367	1.660	6.830
	[Junction_Type=2]	1.095	.405	7.292	1	.007	2.988	1.534	5.820
	[Junction_Type=3]	0[b]	.	.	0	.	.	.	.
	[Posted_speed=1]	.817	.593	1.895	1	.169	2.263	.853	6.006
	[Posted_speed=2]	0[b]	.	.	0	.	.	.	.
	[number_of_lanes=1]	-1.326	.517	6.587	1	.010	.266	.114	.621

Accident Severity[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	90% Confidence Interval for Exp(B) Lower Bound	Upper Bound
	[number_of_lanes=2]	-.402	.232	2.989	1	.084	.669	.456	.981
	[number_of_lanes=3]	0[b]	.	.	0	.	.	.	.
	[v1_type=3]	-.502	.502	1.001	1	.317	.605	.265	1.382
	[v1_type=5]	-.522	.319	2.672	1	.102	.593	.351	1.003
	[v1_type=6]	-.468	.393	1.417	1	.234	.627	.328	1.196
	[v1_type=7]	-.140	.319	.192	1	.661	.870	.515	1.469
	[v1_type=25]	0[b]	.	.	0	.	.	.	.
4	Intercept	2.107	.827	6.484	1	.011			
	[Day_or_Night=1]	-.709	.319	4.945	1	.026	.492	.292	.832
	[Day_or_Night=2]	0[b]	.	.	0	.	.	.	.
	[collision_type=2]	-2.339	.625	14.029	1	.000	.096	.034	.269
	[collision_type=3]	-1.815	.547	11.016	1	.001	.163	.066	.400
	[collision_type=4]	-2.243	.514	19.013	1	.000	.106	.046	.247
	[collision_type=11]	0[b]	.	.	0	.	.	.	.
	[Junction_Type=1]	.794	.680	1.364	1	.243	2.212	.723	6.765
	[Junction_Type=2]	.634	.636	.995	1	.319	1.885	.663	5.362
	[Junction_Type=3]	0[b]	.	.	0	.	.	.	.
	[Posted_speed=1]	2.720	.931	8.546	1	.003	15.184	3.286	70.164
	[Posted_speed=2]	0[b]	.	.	0	.	.	.	.
	[number_of_lanes=1]	-2.263	.941	5.784	1	.016	.104	.022	.489
	[number_of_lanes=2]	-.560	.372	2.262	1	.133	.571	.310	1.054
	[number_of_lanes=3]	0[b]	.	.	0	.	.	.	.
	[v1_type=3]	-1.213	.770	2.486	1	.115	.297	.084	1.054
	[v1_type=5]	-1.541	.441	12.206	1	.000	.214	.104	.442
	[v1_type=6]	-2.268	.730	9.665	1	.002	.103	.031	.344
	[v1_type=7]	-1.344	.435	9.547	1	.002	.261	.127	.533
	[v1_type=25]	0[b]	.	.	0	.	.	.	.

The multinomial logistic regression analysis identified significant factors directly associated with accident severity of crashes happening at unsignalized intersections. Table 1.2 lists the parameter estimates and odds ratio properly adjusting other factors for significant independent variables. The following is the interpretation of the regression results for those variables.

Here six variables including day or night, collision type, junction type, posted speed, number of lanes and impacting vehicle type show significant impact (*i.e. sig < 0.1*) on the severity of the crashes occurring at unsignalized intersections.

Day or Night represents the time of accident as stated in the police reports. Adjusting other variables, table 1.2 shows that there is significant impact of time of accident on severity of accident. The risk of the accident severity being major is 29% lower than the severity being minor when the time of accident is during day as compared to night. Table 5.3 also shows that risk of accident severity being fatal is 51% lower than the severity being minor when the time of accident is during day as compared to night.

Collision type represents the type of collision as stated in the police reports. Adjusting other variables, table 1.2 shows that there is significant impact of collision type on severity of accident. Table 1.2 shows that collision type (Head on collision, hit from behind, hit from the side or others) is not significant enough to have any impact on the risk of accident severity being major as compared to being minor. But Table 1.2 shows that the risk of accident severity being fatal is 90% lower than the severity being minor when the collision is head on as compared to being other. The risk of accident severity being fatal is 83% lower than the severity being minor when the vehicle is hit from back as compared to being other. The risk of accident severity being fatal is 89% lower than the severity being minor when the vehicle is hit from the side as compared to others.

Junction type represents the type of junction at which the crash occurred as stated in police reports. Adjusting other variables, table 1.2 shows that there is significant impact of junction type on severity of accident. Table 1.2 shows that the risk of accident severity being major is 3.367 times higher than the severity being minor if the accident occurs at four-arm junction as compared to Y junction. The risk of accident severity being major is 2.988 times higher than the severity being minor if the accident occurs at T junction as compared to Y junction. Table 5.3 also shows that junction type is not significant enough to have any impact on the risk of accident severity being fatal as compared to being minor.

Posted speed represents the speed limit of the road on which the crash occurred as stated in police reports. Adjusting other variables, table 1.2 shows that there is significant impact of posted speed on severity of accidents. Table 1.2 shows that posted speed is not significant enough to have any impact on the accident severity being major as compared to being minor. Table 1.2 shows that the risk of accident severity being fatal is 15.184 times higher than the severity being minor if the accident occurs on a road with speed limit of 100 as compared to road with speed limit of 40.

Number of lanes represents the number of lanes of the road on which the crash occurred as stated in the police reports. Adjusting other variables, table 5.3 shows that there is significant impact of Number of lanes on severity of accidents. Table 5.3 shows that the risk of accident severity being major is 73% lower than the severity being minor when accident occurs on 6 lane road as compared to 2 lane road. The risk of accident severity being major is 33% lower than the severity being minor when the accident occurs on 4 lane road as compared to 2 lane road. Table 5.3 also shows that the risk of accident severity being fatal is 90% lower than the severity being minor if the accident occurs on 6 lane road as compared to a 2-lane road. The 4 lane roads are not significant enough to have any impact on the risk of severity of accident being fatal relative to severity being minor as compared to 2 lane road.

Impacting vehicle type represents the type of vehicle which strikes the victim vehicle as stated in police reports. Adjusting other variables, table 1.2 shows that there is significant impact of impacting vehicle type on severity of accidents. Table 1.2 shows that impacting vehicle type is not significant enough to have any impact on the risk of accident severity being major as compared to being minor. Table 1.2 shows that, if the impacting vehicle type is light commercial vehicles than it is not significant enough to have any impact on the risk of accident severity being fatal as compared to being minor. The risk of accident severity being fatal is 79% lower than the accident severity being minor if the impacting vehicle is car as compared to heavy vehicles. The risk of accident severity being fatal is 90 % lower than the accident severity being minor if the impacting vehicle is an auto rickshaw as compared to heavy vehicles. The risk of accident severity being fatal is 74% lower than the accident severity being minor if the impacting vehicle is motorcycle as compared to heavy vehicles.

Model 2 – Motorized two wheelers vehicle crashes occurring at all intersections

The model is developed to see which of the parameters taken into consideration influence the severity of the motorized two wheelers vehicle accidents occurring at all intersections in Vadodara city. The accident severity is the dependent variable. It is a categorical variable. The three categories of accident severity are minor accidents, major accidents and fatal accidents.

The confidence interval is set at 90 %. So, the parameters whose p-value (shown under the *Sig.* column in the parameter estimates table) are < 0.1 are said to have an impact on the dependent variable (i.e. accident severity). The parameters whose p-value was very high than 0.1 are eliminated. Then after trial and error of different combinations of the remaining parameters the final parameters taken into consideration are: Day or night, collision type, junction type, number of lanes, impacting vehicle type and victim age group.

The parameter estimates table of the multinomial logistic regression performed using these parameters as independent variables and accident severity as dependent variable is discussed below.

Goodness of Fit

The p-value is 0.715 for deviance chi-square statistic and is, therefore not statistically significant. Based on the measure stated before, the model fits the data well. It is significant for Pearson chi-square statistic but the result from the two can vary, as seen here.

Parameter Estimates

Table1.3 Parameter estimates for motorized two-wheeler vehicle crashes at all intersection

Accident Severity		B	Std. Error	Wald	df	Sig.	Exp(B)	90% Confidence Interval for Exp(B)	
								Lower Bound	Upper Bound
3	Intercept	1.534	.804	3.637	1	.057			
	[Day_or_Night=1]	-.404	.196	4.253	1	.039	.668	.484	.922
	[Day_or_Night=2]	0b	.	.	0	.	.	.	.
	[collision_type=2]	-.320	.493	.421	1	.517	.726	.323	1.635
	[collision_type=3]	-.608	.491	1.538	1	.215	.544	.243	1.220
	[collision_type=4]	-.546	.473	1.331	1	.249	.579	.266	1.262
	[collision_type=11]	0b	.	.	0	.	.	.	.
	[Junction_Type=1]	1.003	.367	7.485	1	.006	2.727	1.492	4.986
	[Junction_Type=2]	.722	.357	4.092	1	.043	2.059	1.144	3.704
	[Junction_Type=3]	0b	.	.	0	.	.	.	.

Accident Severity		B	Std. Error	Wald	df	Sig.	Exp(B)	90% Confidence Interval for Exp(B)	
								Lower Bound	Upper Bound
	[number_of_lanes=1]	-.738	.379	3.790	1	.052	.478	.257	.892
	[number_of_lanes=2]	-.551	.255	4.679	1	.031	.576	.379	.876
	[number_of_lanes=3]	0^b	.	.	0	.	.	.	.
	[v1_type=3]	-.852	.597	2.037	1	.154	.427	.160	1.139
	[v1_type=5]	-.492	.399	1.519	1	.218	.612	.317	1.179
	[v1_type=6]	-1.025	.496	4.275	1	.039	.359	.159	.811
	[v1_type=7]	-.239	.397	.362	1	.547	.787	.410	1.513
	[v1_type=25]	0^b	.	.	0	.	.	.	.
	[vt1_agegroup=2]	-.344	.726	.225	1	.635	.709	.215	2.338
	[vt1_agegroup=3]	-.485	.371	1.713	1	.191	.616	.335	1.133
	[vt1_agegroup=4]	-.041	.363	.013	1	.911	.960	.529	1.743
	[vt1_agegroup=5]	0^b	.	.	0	.	.	.	.
4	Intercept	3.133	1.292	5.877	1	.015			
	[Day_or_Night=1]	-.573	.374	2.350	1	.125	.564	.305	1.043
	[Day_or_Night=2]	0^b	.	.	0	.	.	.	.
	[collision_type=2]	-2.788	.689	16.359	1	.000	.062	.020	.191
	[collision_type=3]	-2.694	.635	17.982	1	.000	.068	.024	.192
	[collision_type=4]	-2.672	.578	21.396	1	.000	.069	.027	.179
	[collision_type=11]	0^b	.	.	0	.	.	.	.
	[Junction_Type=1]	.178	.683	.068	1	.795	1.195	.388	3.676
	[Junction_Type=2]	.236	.649	.132	1	.716	1.266	.436	3.681
	[Junction_Type=3]	0^b	.	.	0	.	.	.	.
	[number_of_lanes=1]	-1.489	.870	2.928	1	.087	.226	.054	.944
	[number_of_lanes=2]	-.866	.429	4.072	1	.044	.421	.208	.852
	[number_of_lanes=3]	0^b	.	.	0	.	.	.	.
	[v1_type=3]	-2.507	1.217	4.242	1	.039	.082	.011	.604
	[v1_type=5]	-2.232	.572	15.243	1	.000	.107	.042	.275
	[v1_type=6]	-2.978	1.126	6.997	1	.008	.051	.008	.324
	[v1_type=7]	-1.993	.550	13.143	1	.000	.136	.055	.337
	[v1_type=25]	0^b	.	.	0	.	.	.	.
	[vt1_agegroup=2]	1.860	1.136	2.682	1	.101	6.423	.992	41.593
	[vt1_agegroup=3]	.372	.854	.189	1	.663	1.450	.356	5.908
	[vt1_agegroup=4]	.469	.844	.308	1	.579	1.598	.398	6.406
	[vt1_agegroup=5]	0^b	.	.	0	.	.	.	.

The multinomial logistic regression analysis identified significant factors directly associated with accident severity of motorized two-wheeler vehicle crashes occurring at all intersections. Table 1.4 lists the parameter estimates and odds ratio properly adjusting other factors for significant independent variables. The following is the interpretation of the regression results for those variables.

Here five variables including day or night, collision type, junction type, number of lanes and impacting vehicle type show significant impact (*i.e. sig* < *0.1*) on the severity of the motorized two-wheeler vehicle crashes occurring at all intersections.

Day or Night represents the time of accident as stated in the police reports. Adjusting other variables, table 1.4 shows that there is significant impact of time of accident on severity of accident. The risk of the accident severity being major is 61% lower than the severity being minor when the time of accident is during day as compared to night. Table 5.3 also shows that crash occurring at day or night is not significant enough to have any impact on the risk of accident severity being fatal as compared to the severity being minor.

Collision type represents the type of collision as stated in the police reports. Adjusting other variables, table 1.4 shows that there is significant impact of collision type on severity of accident. Table 1.4 shows that collision type (Head on collision, hit from behind, hit from the side or others) is not significant enough to have any impact on the risk of accident severity being major as compared to being minor. But table 1.4 shows that the risk of accident severity being fatal is 38% lower than the severity being minor when the collision is head on as compared to being other. The risk of accident severity being fatal is 32% lower than the severity being minor when the vehicle is hit from back as compared to being other. The risk of accident severity being fatal is 31% lower than the severity being minor when the vehicle is hit from the side as compared to others.

Junction type represents the type of junction at which the crash occurred as stated in police reports. Adjusting other variables, table 1.4 shows that there is significant impact of junction type on severity of accident. Table 1.4 shows that the risk of accident severity being major is 2.727 times higher than the severity being minor if the accident occurs at four-arm junction as compared to y junction. The risk of accident severity being major is 1.266 times higher than the severity being minor if the accident occurs at T junction as compared to Y junction. Table 5.3 also shows that junction type is not significant enough to have any impact on the risk of accident severity being fatal as compared to being minor.

Number of lanes represents the number of lanes of the road on which the crash occurred as stated in the police reports. Adjusting other variables, table 1.4 shows that there is significant impact of Number of lanes on severity of accidents. Table 1.4 shows that the risk of accident severity being major is 52% lower than the severity being minor when accident occurs on 6 lane road as compared to 2 lane road. The risk of accident severity being major is 42% lower than the severity being minor when the accident occurs on 4 lane road as compared to 2 lane road. Table 5.3 also shows that the risk of accident severity being fatal is 77% lower than the severity being minor if the accident occurs on 6 lane road as compared to a 2-lane road. The risk of accident severity being fatal is 58 % lower than the severity being minor if the accident occurs on 4 lane road as compared to a 2-lane road.

Impacting vehicle type represents the type of vehicle which strikes the victim vehicle as stated in police reports. Adjusting other variables, table 1.4 shows that there is significant impact of impacting vehicle type on severity of accidents. Table 1.4 shows that if the impacting vehicles are light commercial vehicles, cars or motorized two wheelers relative to the impacting vehicle being heavy vehicles, it is not significant enough to have any impacton the risk of accident severity being major as compared to being minor. Table 1.4 shows that the risk of accident severity being major is 64% lower than the accident severity being minor if the impacting vehicle is auto rickshaw as compared to heavy vehicles. The risk of accident severity being fatal is 92% lower than the accident severity being minor if the impacting vehicle is light commercial vehicle as compared to heavy vehicles. The risk of accident severity being fatal is 89 % lower than the accident severity being minor if the impacting vehicle is a car as compared to heavy vehicles. The risk of accident severity being fatal is 95% lower than the accident severity being minor if the impacting vehicle is auto rickshaw as compared to heavy vehicles. The risk of accident severity being fatal is 86% lower than the accident severity being minor if the impacting vehicle is two-wheeler as compared to heavy vehicles.

Conclusion

Present study attempts to develop model to predict the accident severity based on the influence of various factors. The factors considered in this study for developing the model were vehicle characteristics, crash characteristics, victim characteristics and roadway features. The accident severity studied are fatal, major and minor as reported in police data in the form of FIR. On developing the model based on these factors following conclusions were derived:

At unsignalized intersections, major accidents and fatal accidents are more likely to happen at night than at day. Similarly, when model was developed for only motorized two-wheeler crashes at all intersections, major accidents and fatal accidents are more likely to happen at night than during day. Low visibility and late-night fatigue may delay driver's reaction at the impending collision with another vehicle. The road users are less during night in the urban areas, so the drivers may be inclined to more risk-taking behaviour such as driving beyond the speed limit. In order to reduce night time crash severity, drivers should remain alert and not be tempted to increase speed to such an extent that makes it difficult to control the vehicle.

At unsignalized intersections, major accidents and fatal accidents are more likely to happen on two lane roads compared to six lane or four lane roads. Similarly, when a model was developed for only motorized two-wheeler crashes at all intersections, major accidents and fatal accidents are more likely to happen 2 lane roads compared to 6 lane or 4 lane roads. Almost half of the crashes on 2 lane roads were undivided, which may be a factor.

At unsignalized intersections, major accidents are more likely to happen at four arm junction than at T junction and Y junction. Similarly, when a model was developed for crashes for only motorized two-wheeler vehicle crashes at all intersections, major accidents are more likely to happen at four arm junctions as compared to T junctions and Y Junctions. In this study majority of the accidents at unsignalized intersections occurred at T junctions. Most of the accidents at roundabout intersections occurred at four arm junctions.

At unsignalized intersections, fatal accidents are more likely to happen at roads with posted speed of 100. So fatal accidents at unsignalized intersections are more likely to happen if the vehicles at travelling at higher speeds. In this study, majority of the accidents at unsignalized intersections occurred on the roads with posted speed of 40.

At unsignalized intersections, fatal accidents are more likely to happen if impacting vehicle type is a heavy vehicle compared to any other vehicle type. When heavy vehicles are the impacting vehicle type at unsignalized intersections, heavy vehicles and motorcycles make up most of the victim vehicle types.

Proper measures like speed breakers warning signs for speed limits etc. must be taken to reduce speed at all intersections especially at night. Awareness must be raised among road users to follow traffic rules even at night when traffic flow is less.Safety awareness campaign for drivers such as wearing seat belts, not talking on the mobile phone while driving etc. must be promoted and enforced strictly.Proper measures must be taken to improve road safety on two lane roads of the city. More two-lane roads may be converted from undivided to divided.A longer perception reaction time at night will result in higher impact for the same driving speed because the vehicle has a shorter time to slow down. So, countermeasures that will enhance the sight distance of drivers and reduce the perception response time including the use of more conspicuous and reflective signs to indicate nearby intersection may be considered.In future when planning new roads T junctions may be preferred over four arm junctions.

Future Scope

After identifying accident hotspots, accident severity analysis can be done using primary data such as traffic volume and vehicle speed on particular road sections. Further study can be done to analyze the factors affecting accident severity at unsignalized intersections during night. More in depth study can also be done to determine the different factors affecting accident severity at different junction types such as four arm junction, T junction and Y junction. Effect of roadway conditions and compliance of traffic rules such as wearing seat belts, helmets etc. can also be considered for analysis of accident severity.

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